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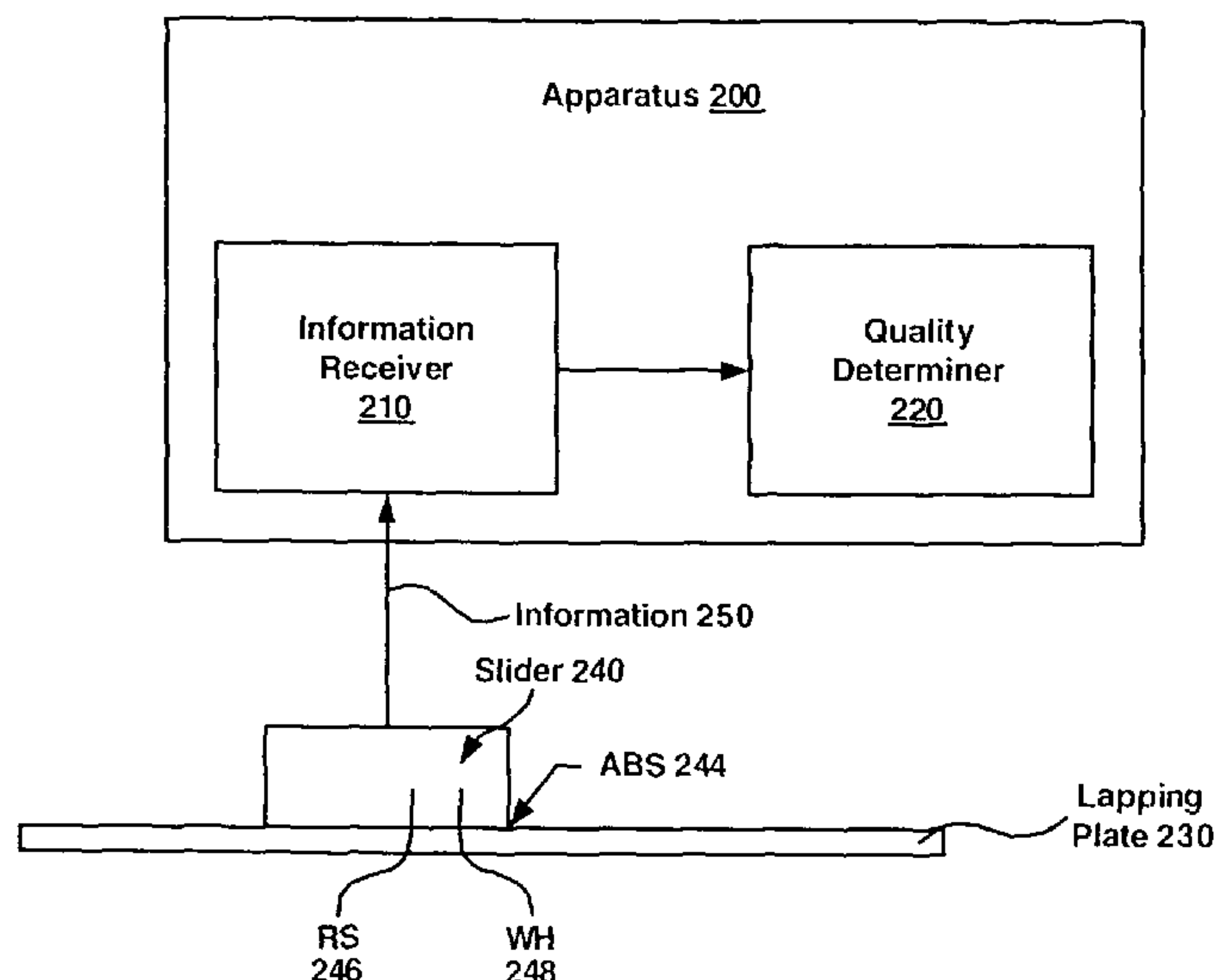
Primary Examiner — Robert Scruggs

(57) **ABSTRACT**

Embodiments of the present invention pertain to a evaluating the quality of a lapping plate. In one embodiment, an information receiver receives information while the lapping plate is being used to lap a slider. The information indicates the quality of a lapping plate. A quality determiner that evaluates the quality of the lapping plate based on the information while the lapping plate is being used to lap the slider.

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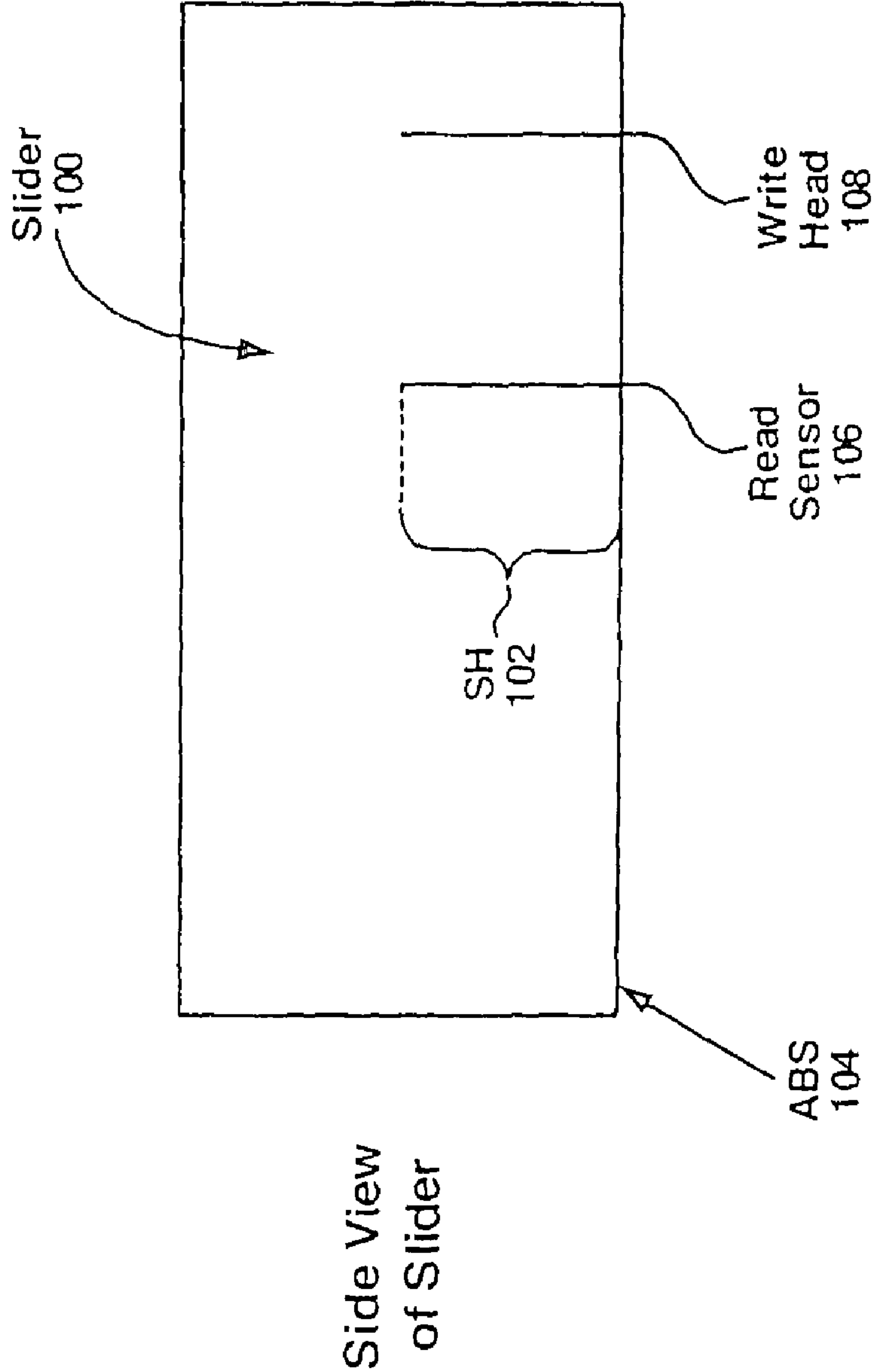
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PRIOR ART

FIG. 1

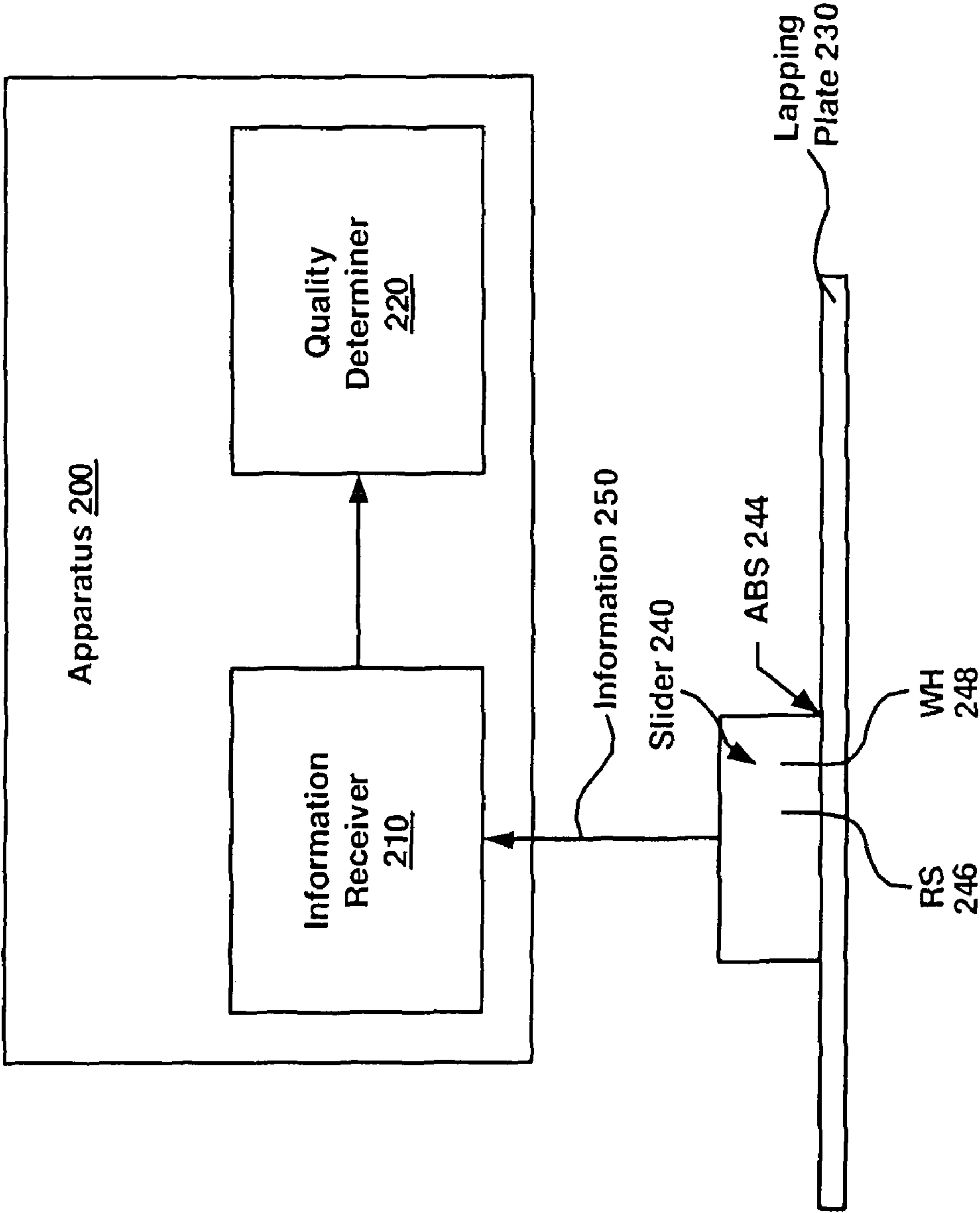


FIG. 2

Bottom View

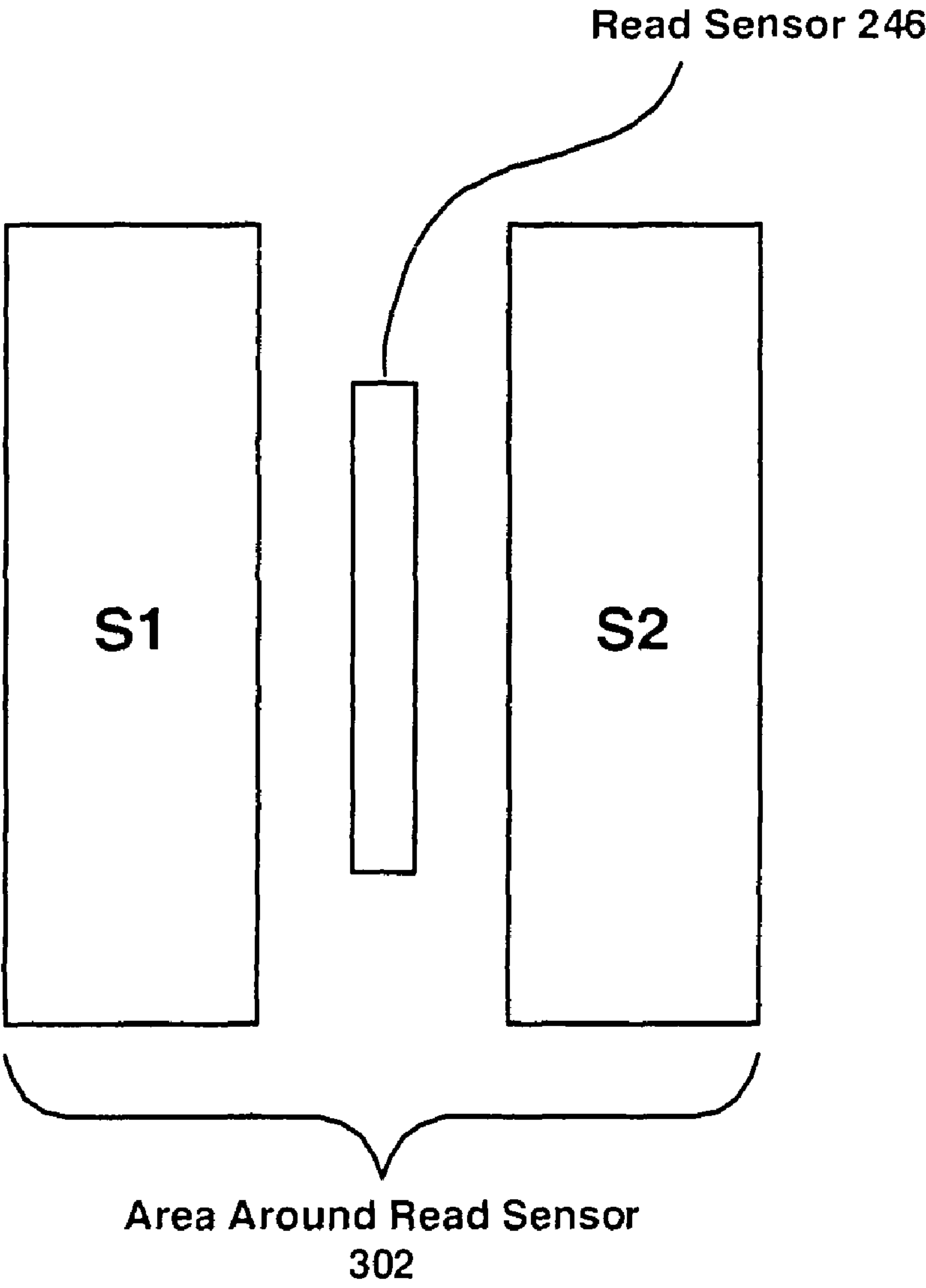


FIG. 3A

Bottom View

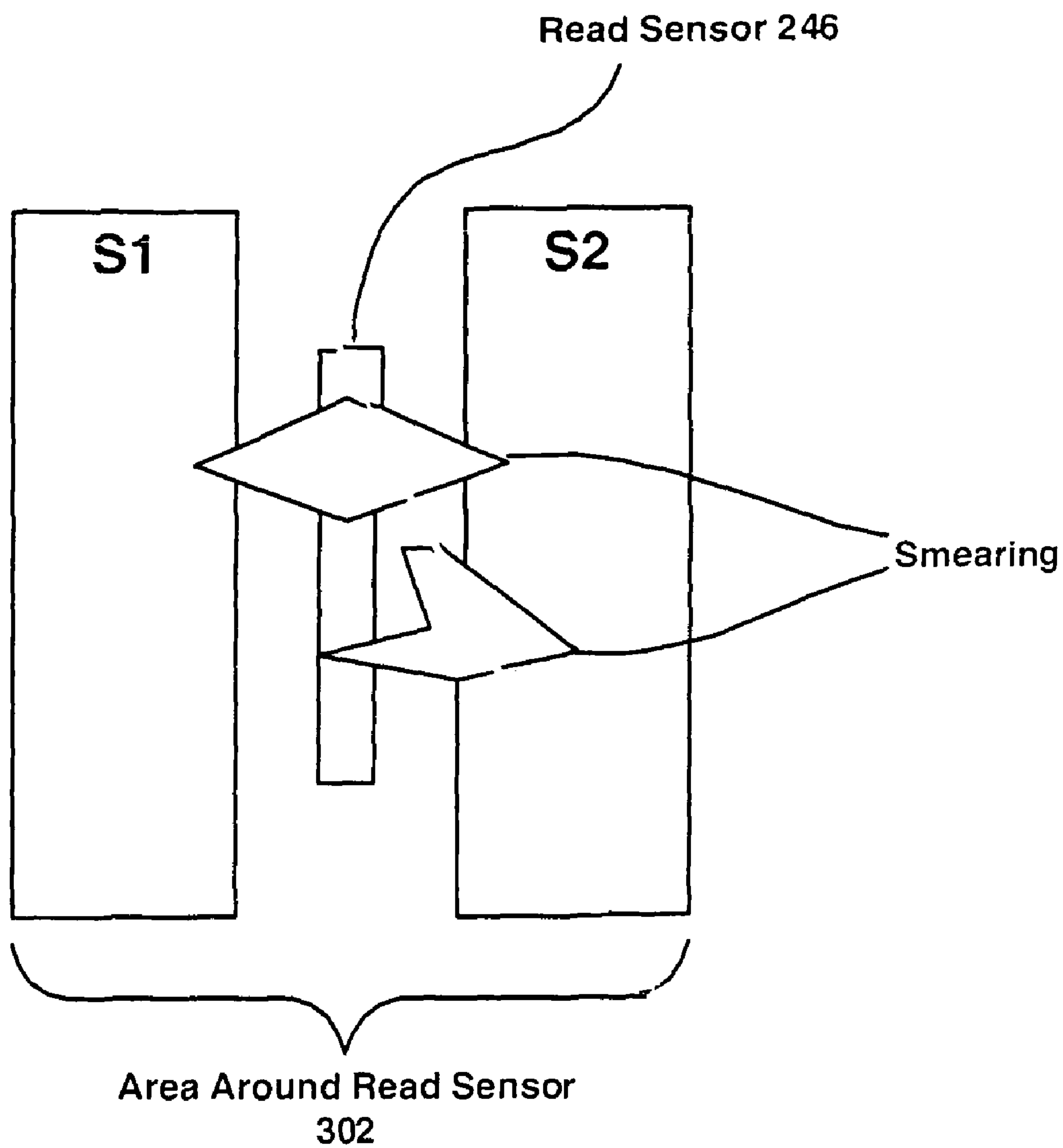
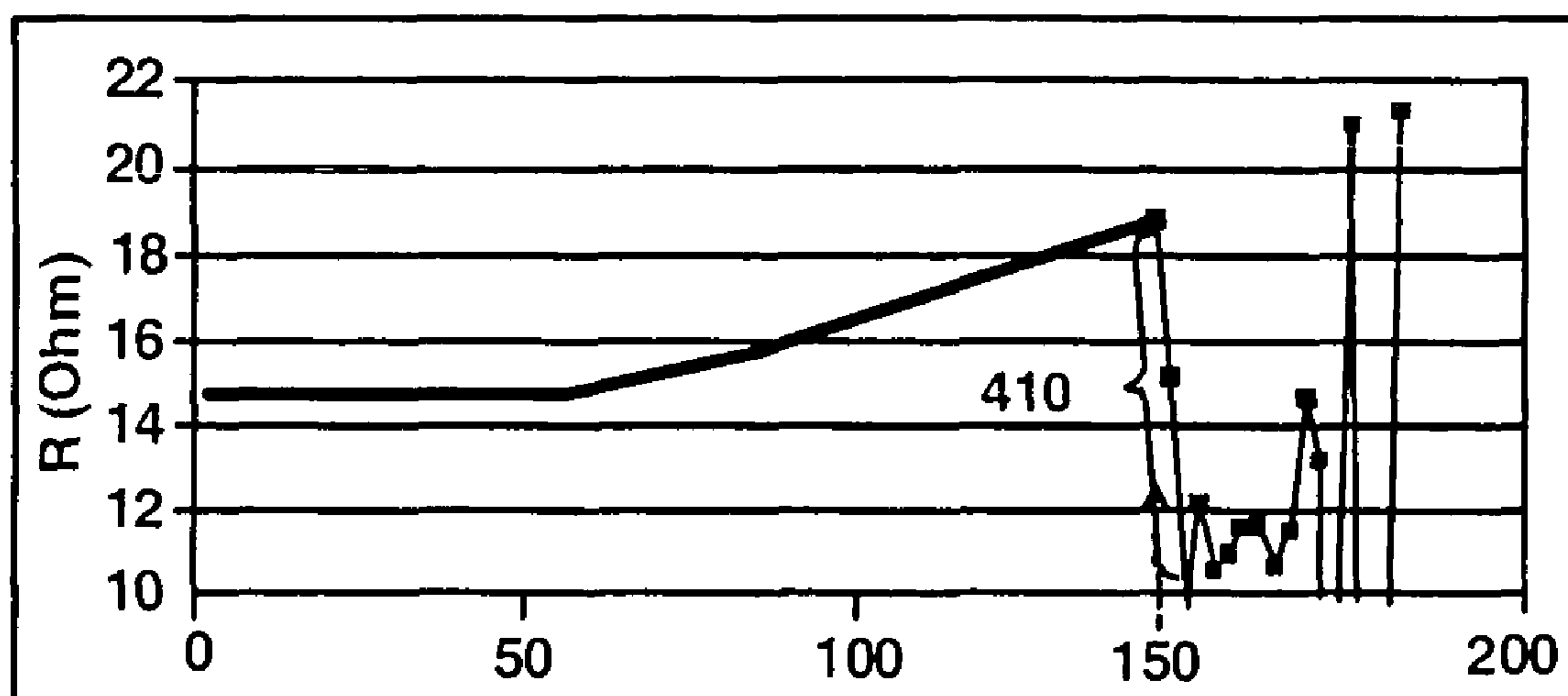
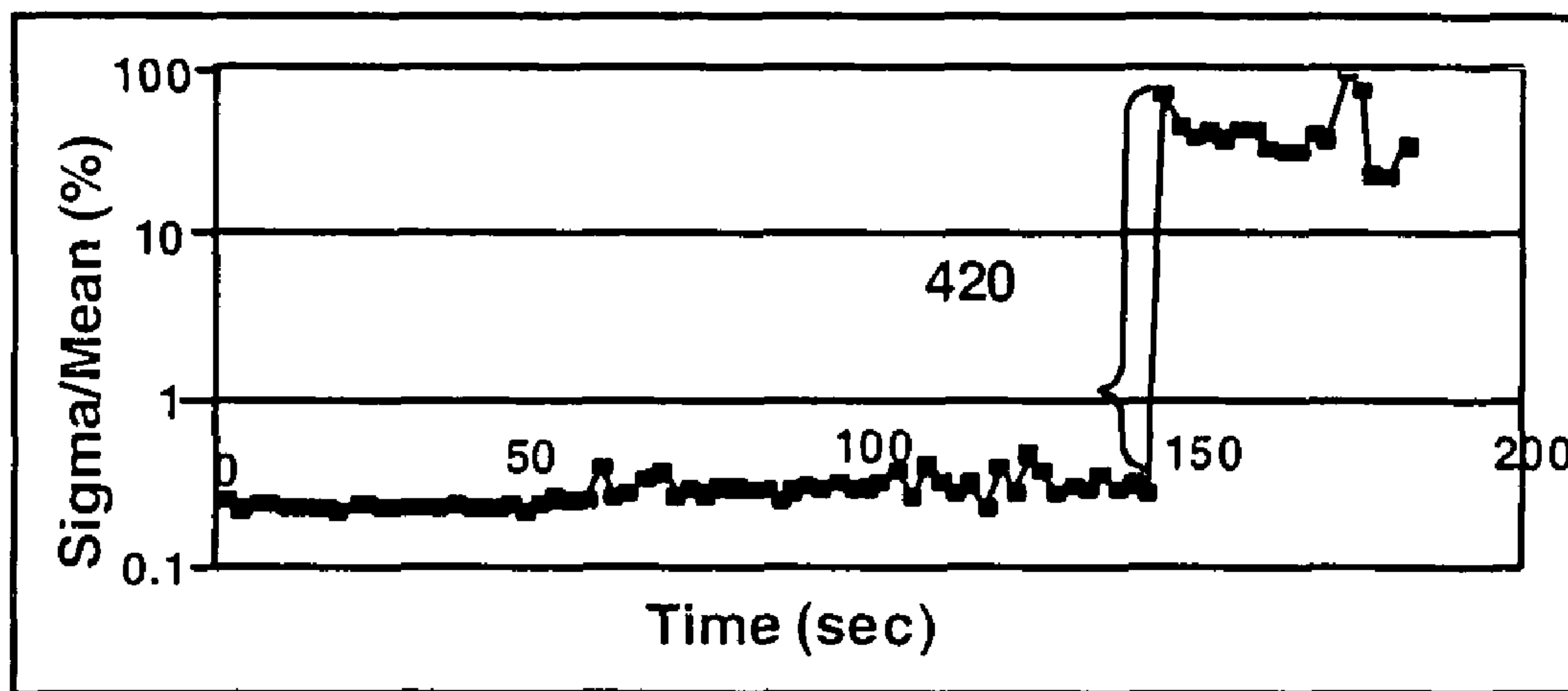


FIG. 3B

**FIG. 4A**

**FIG. 4B**

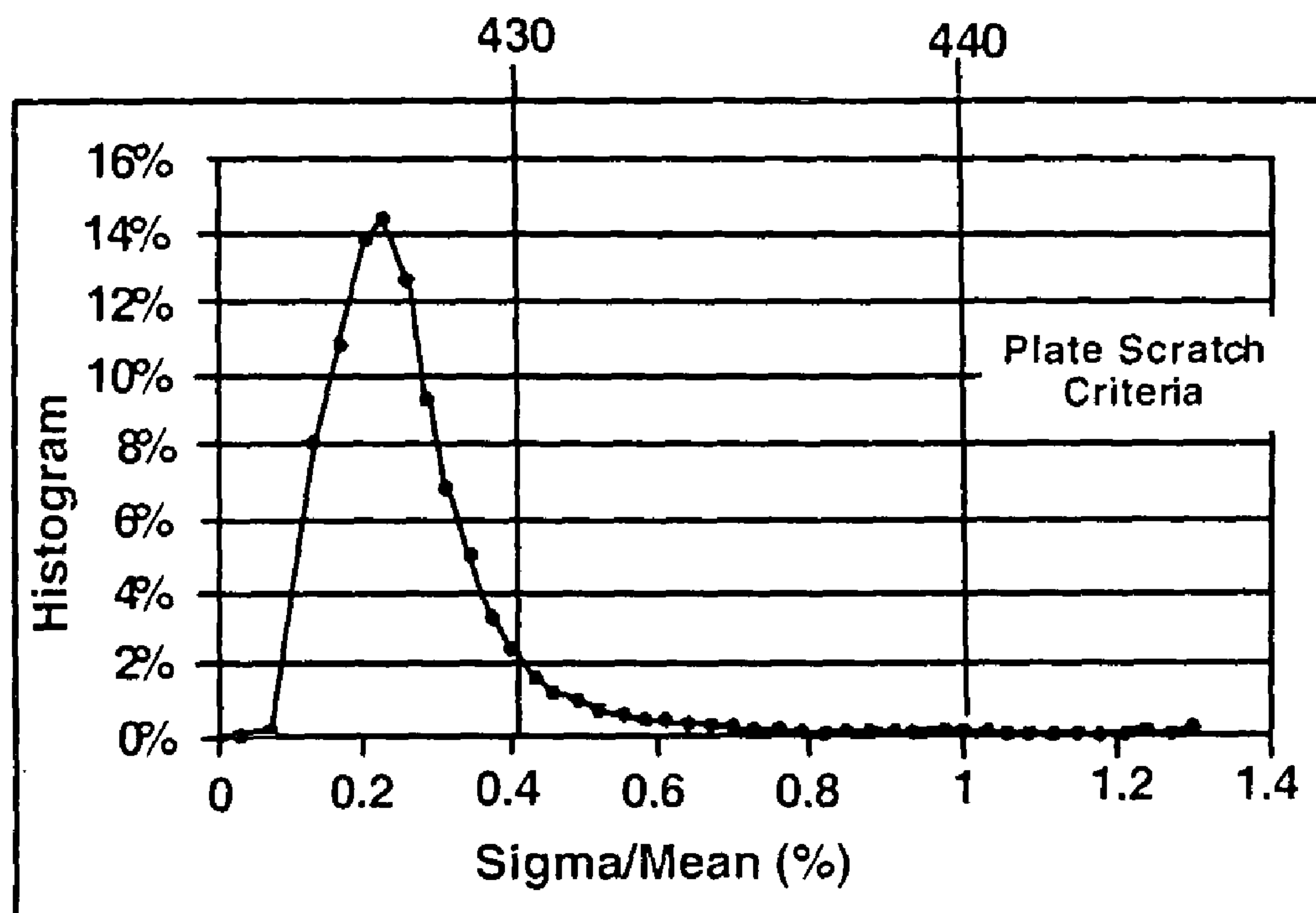


FIG. 4C

Side View

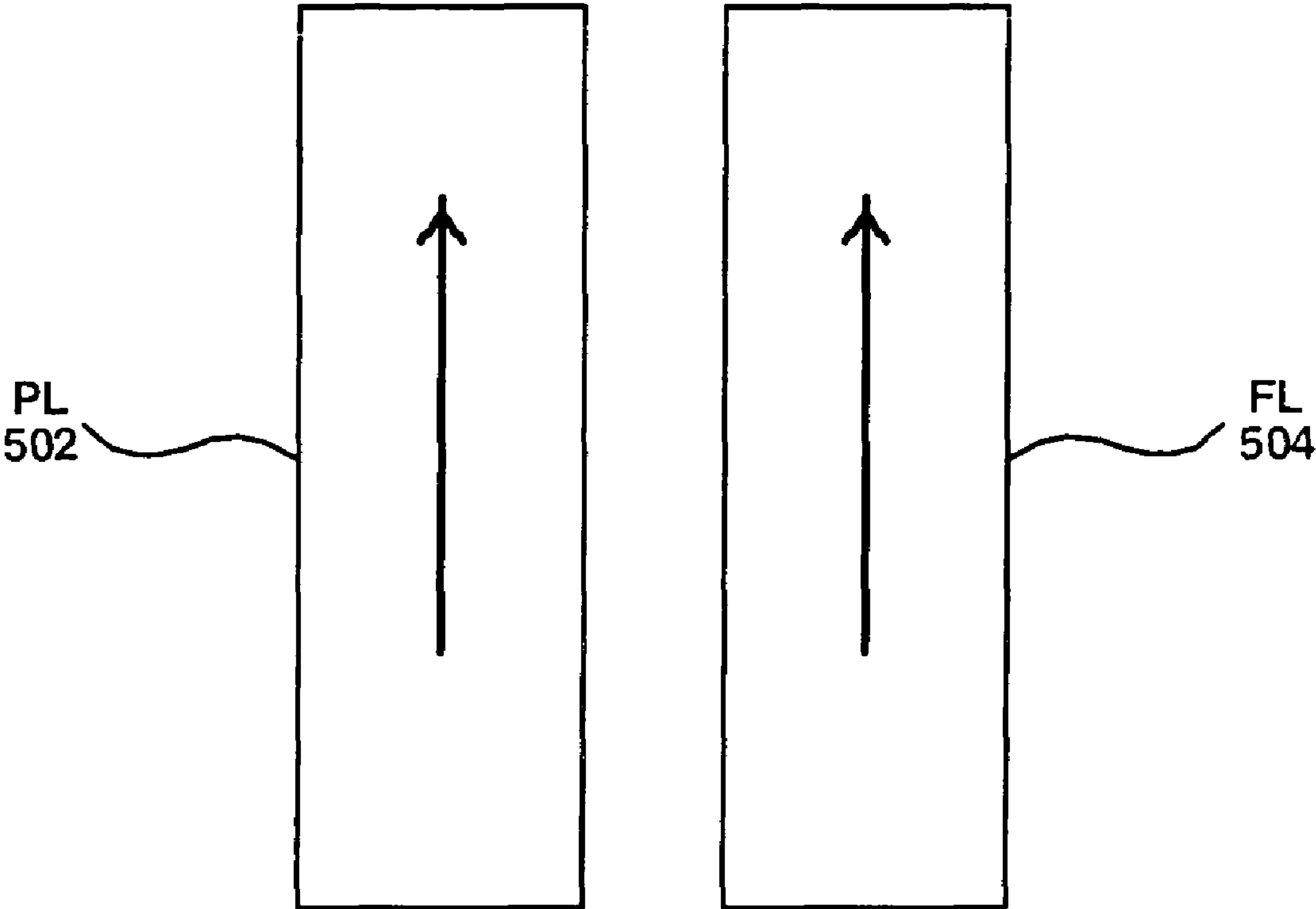


FIG. 5A

Side View

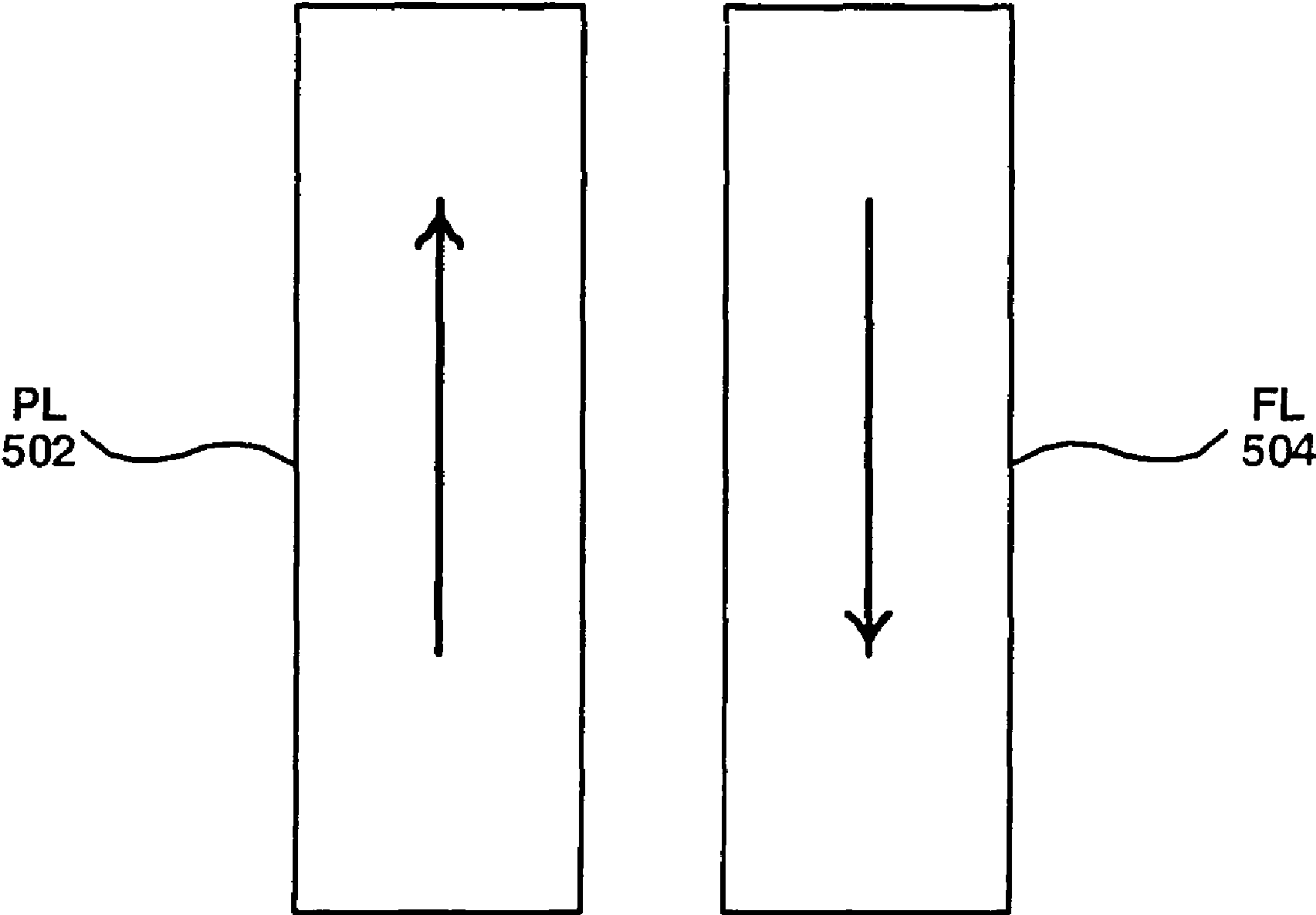


FIG. 5B

Side View

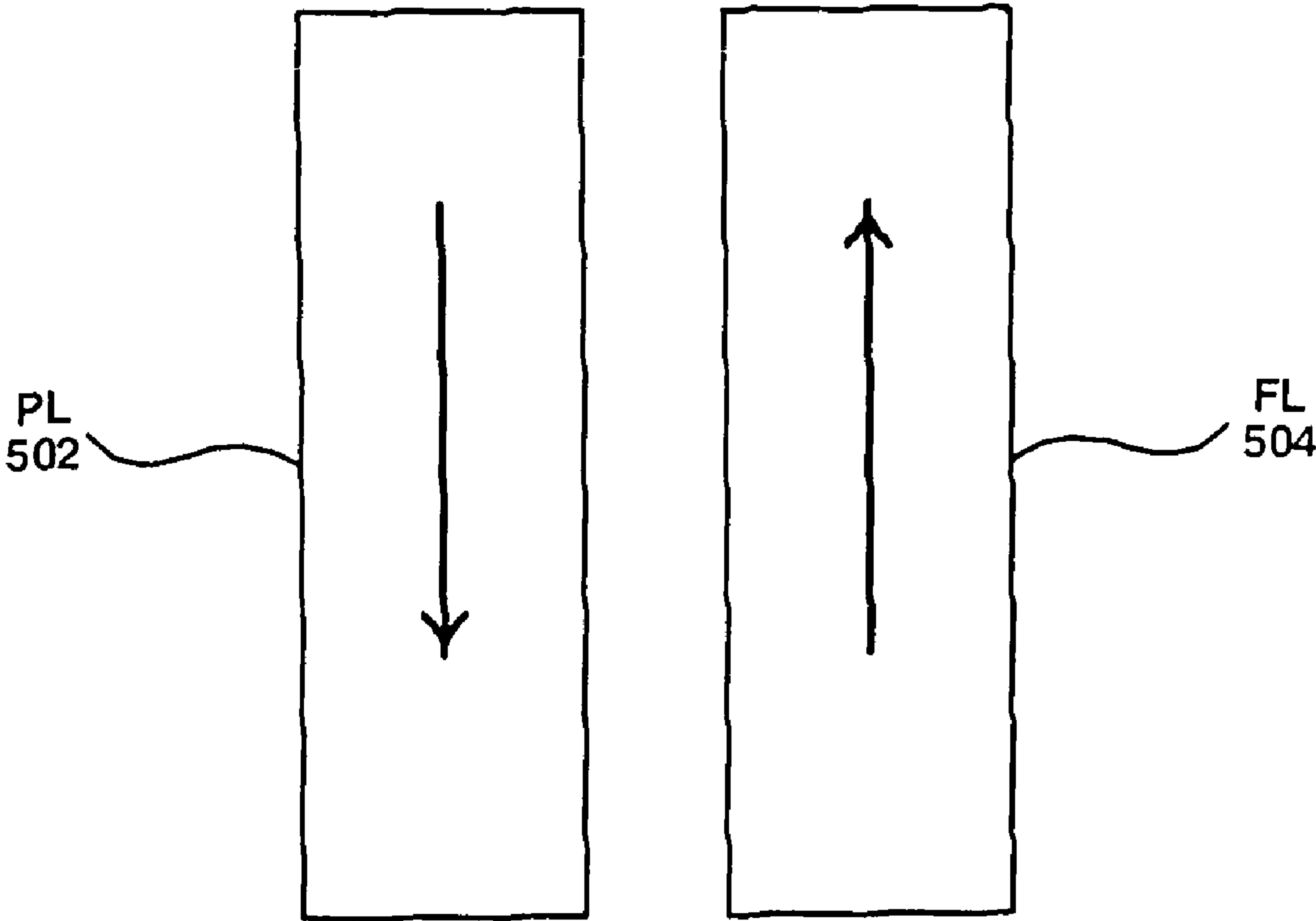


FIG. 5C

Side View

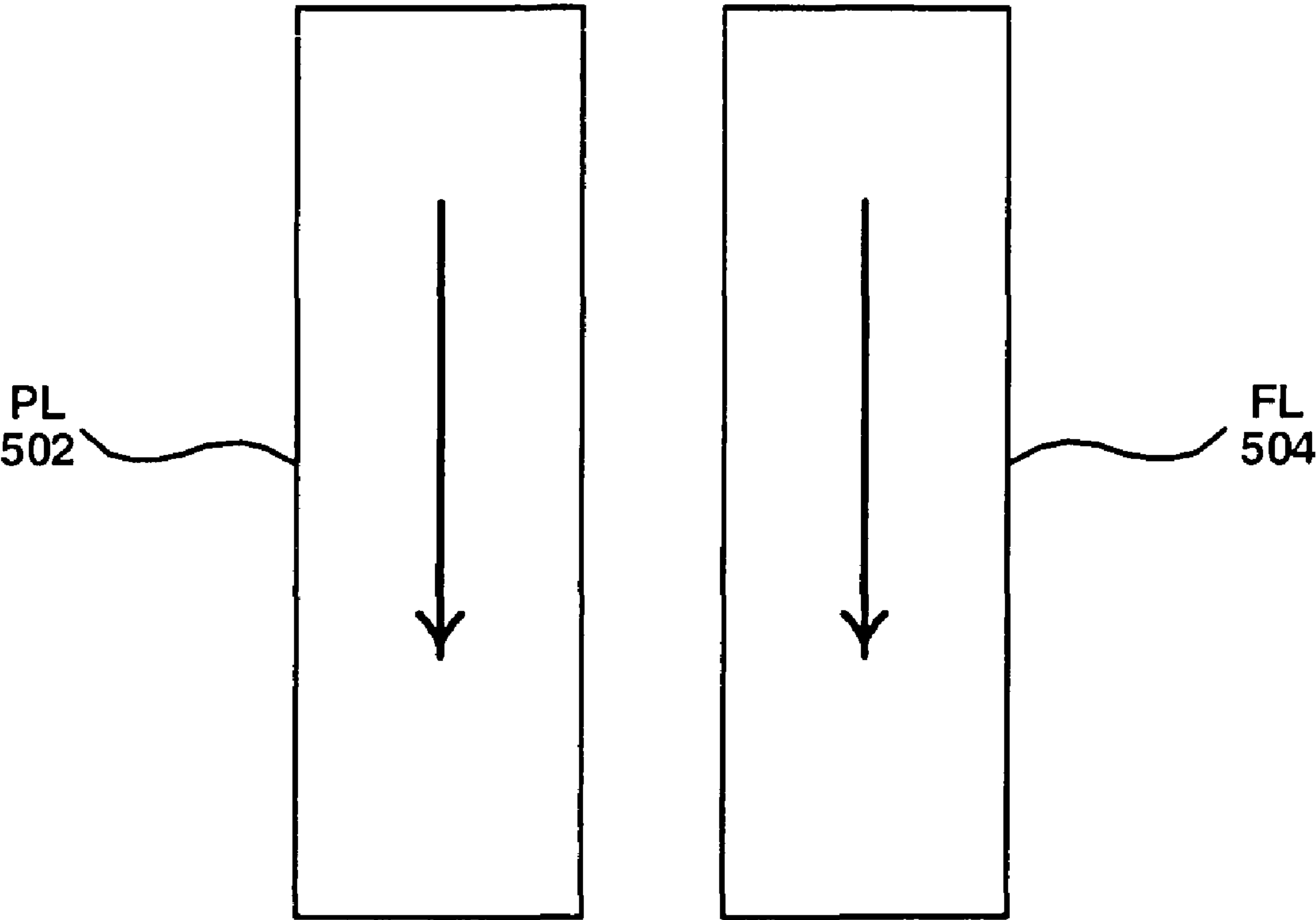


FIG. 5D

Side View

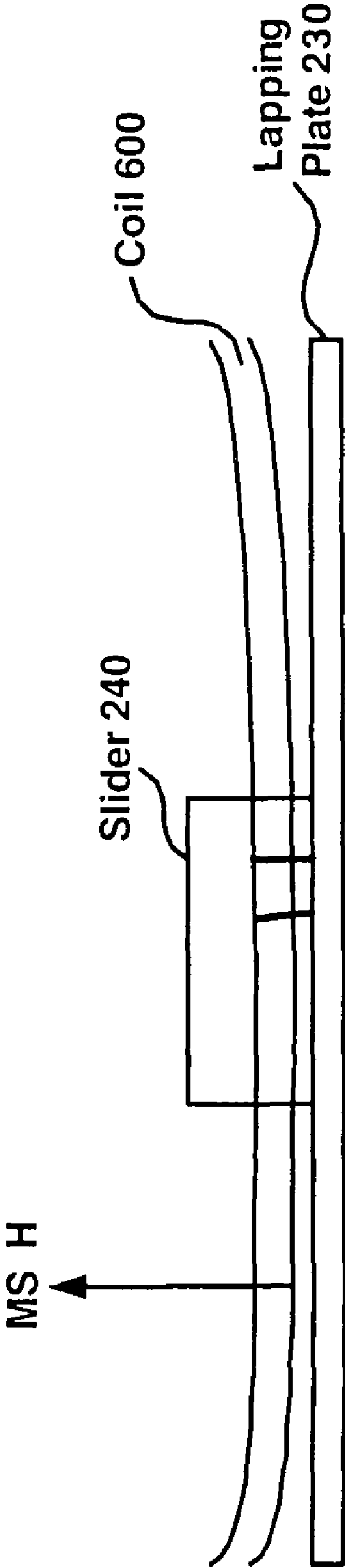


FIG. 6A

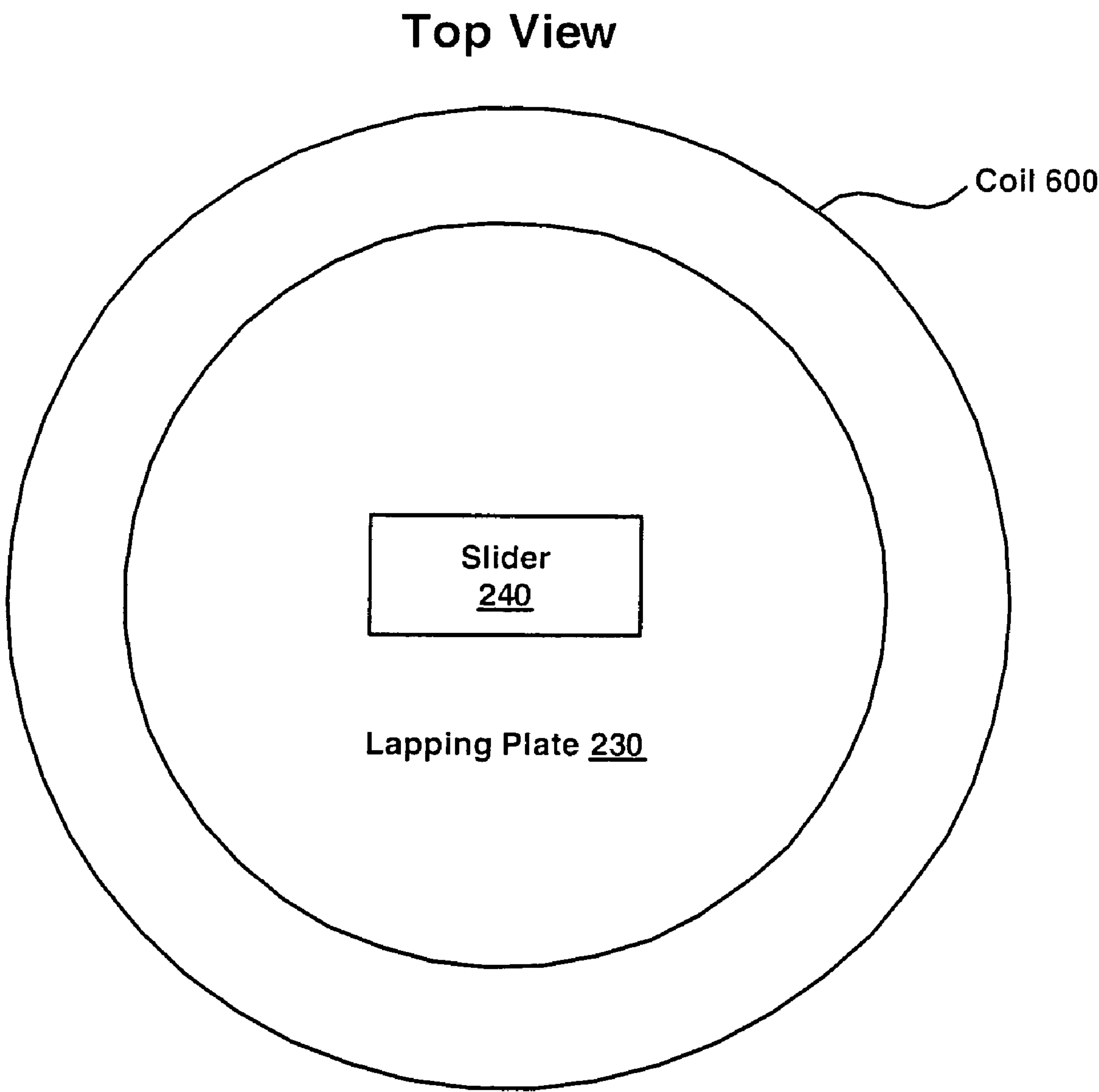


FIG. 6B

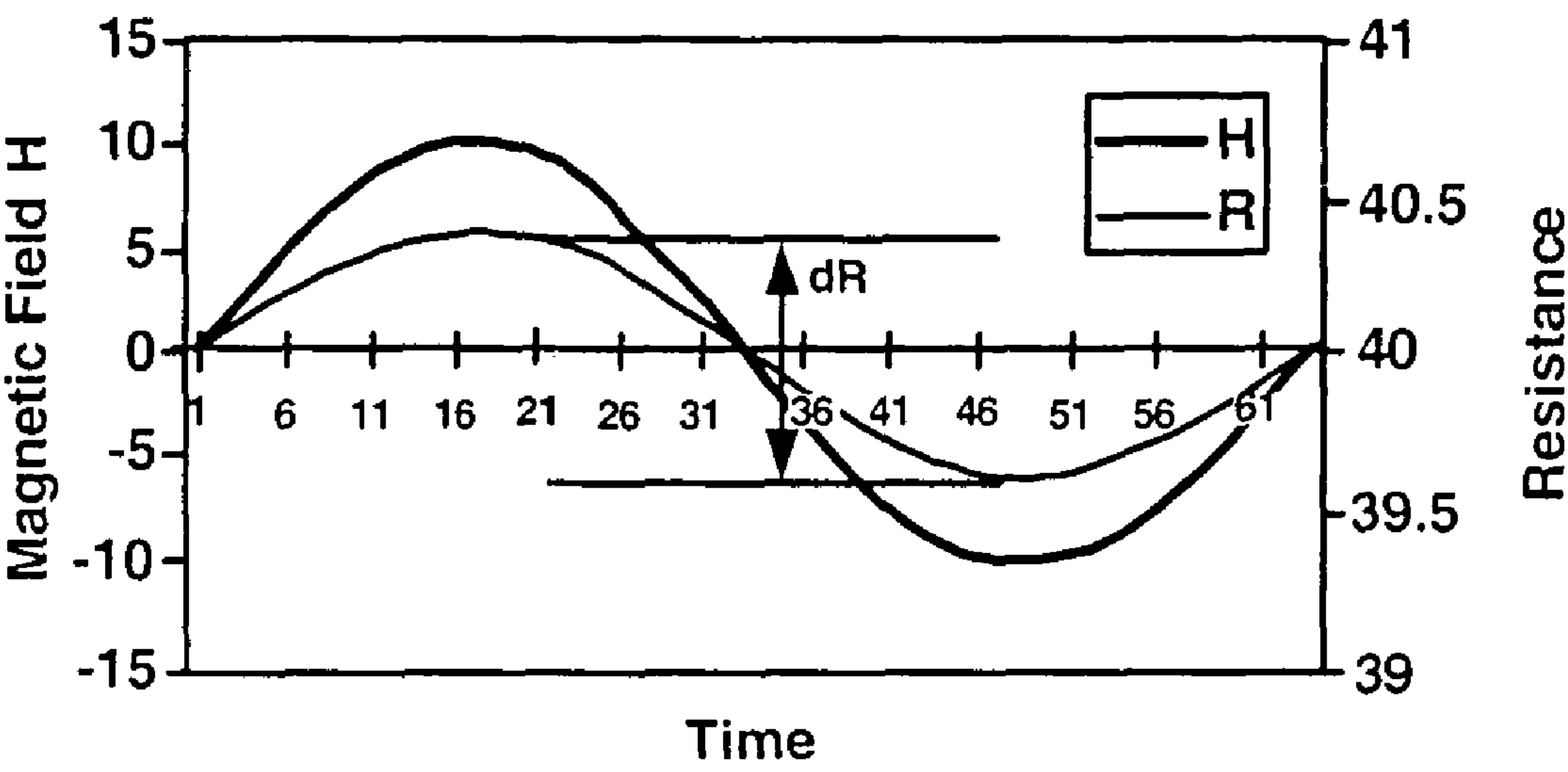


FIG. 7A

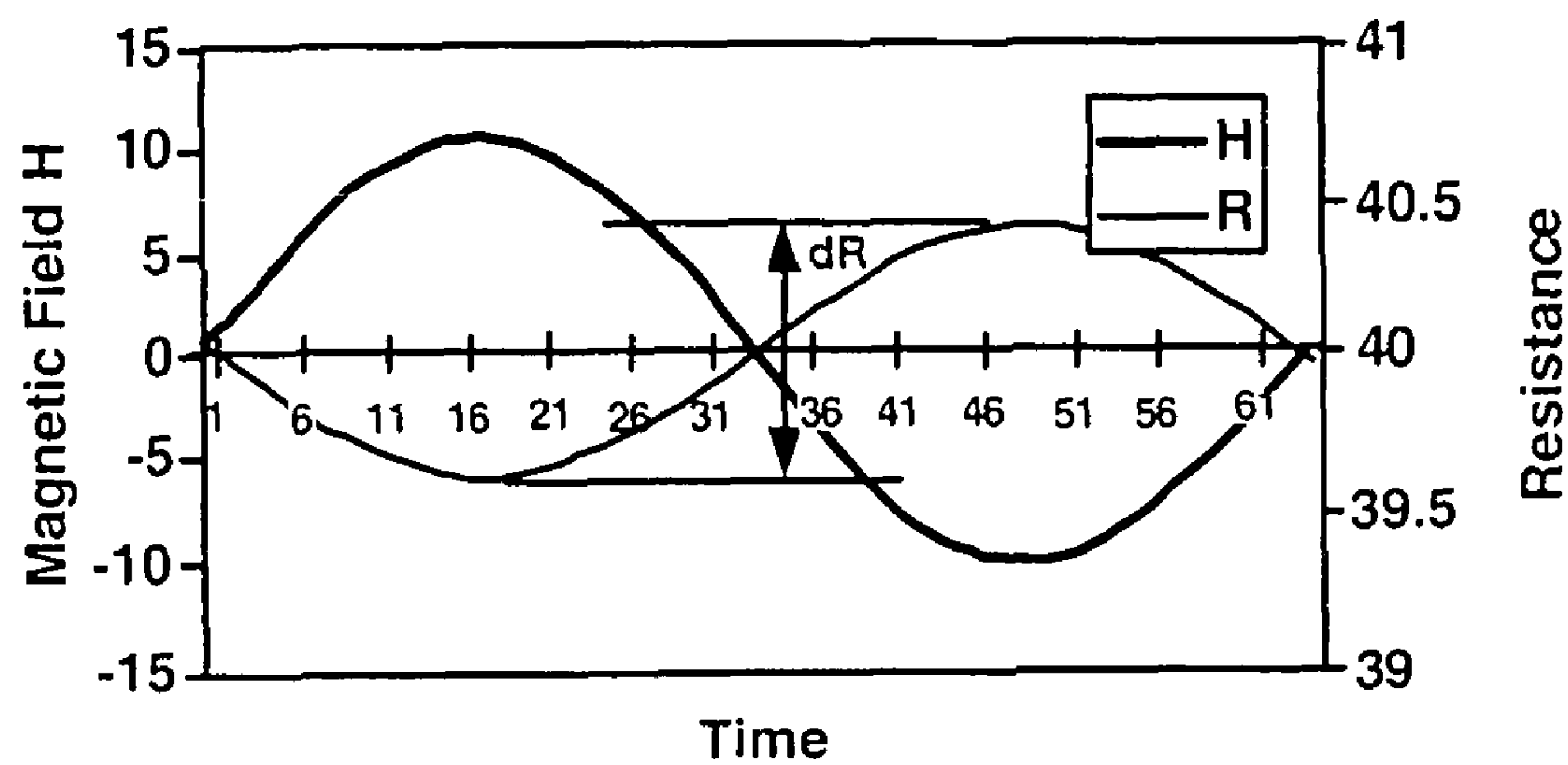


FIG. 7B

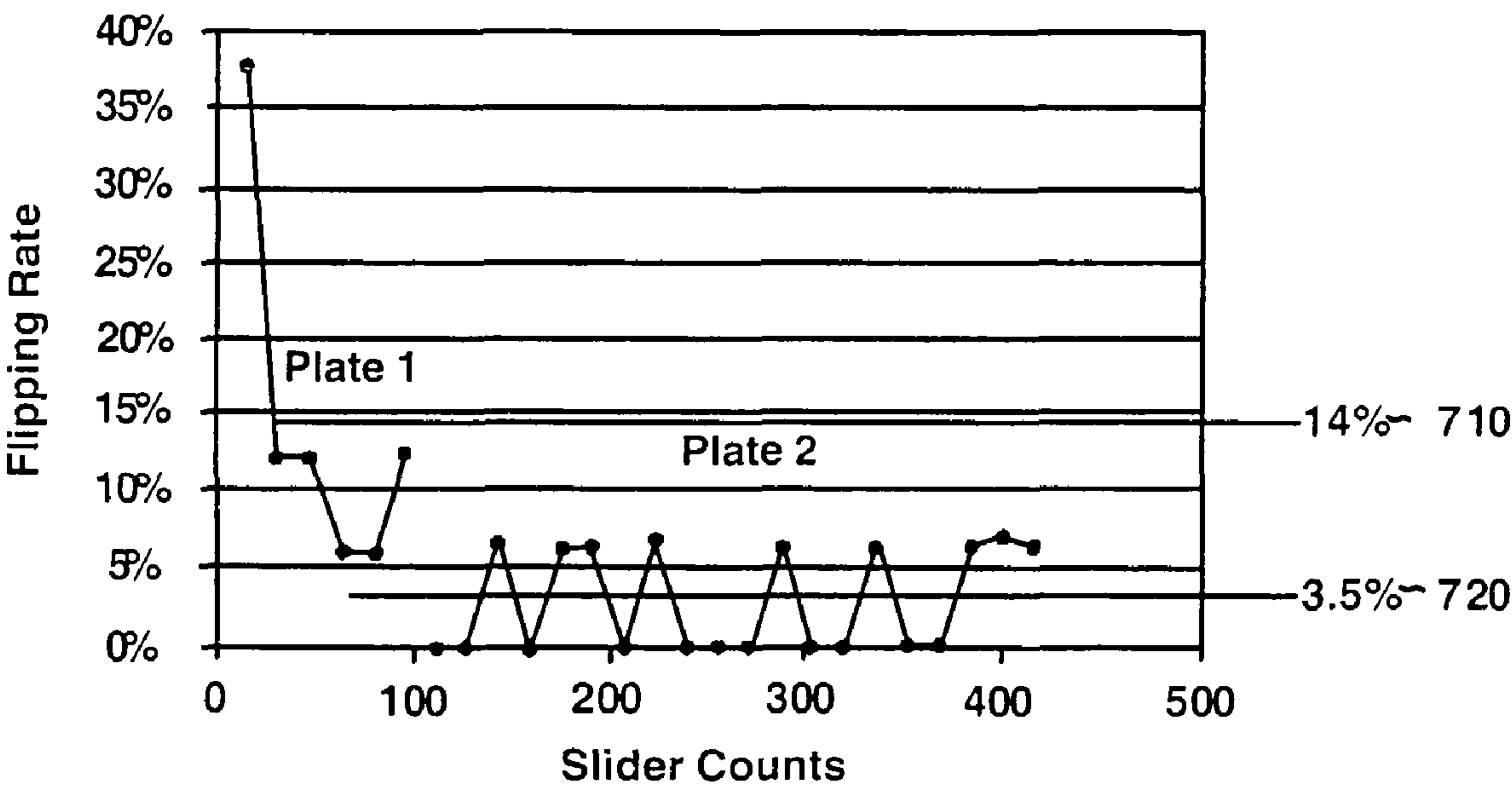
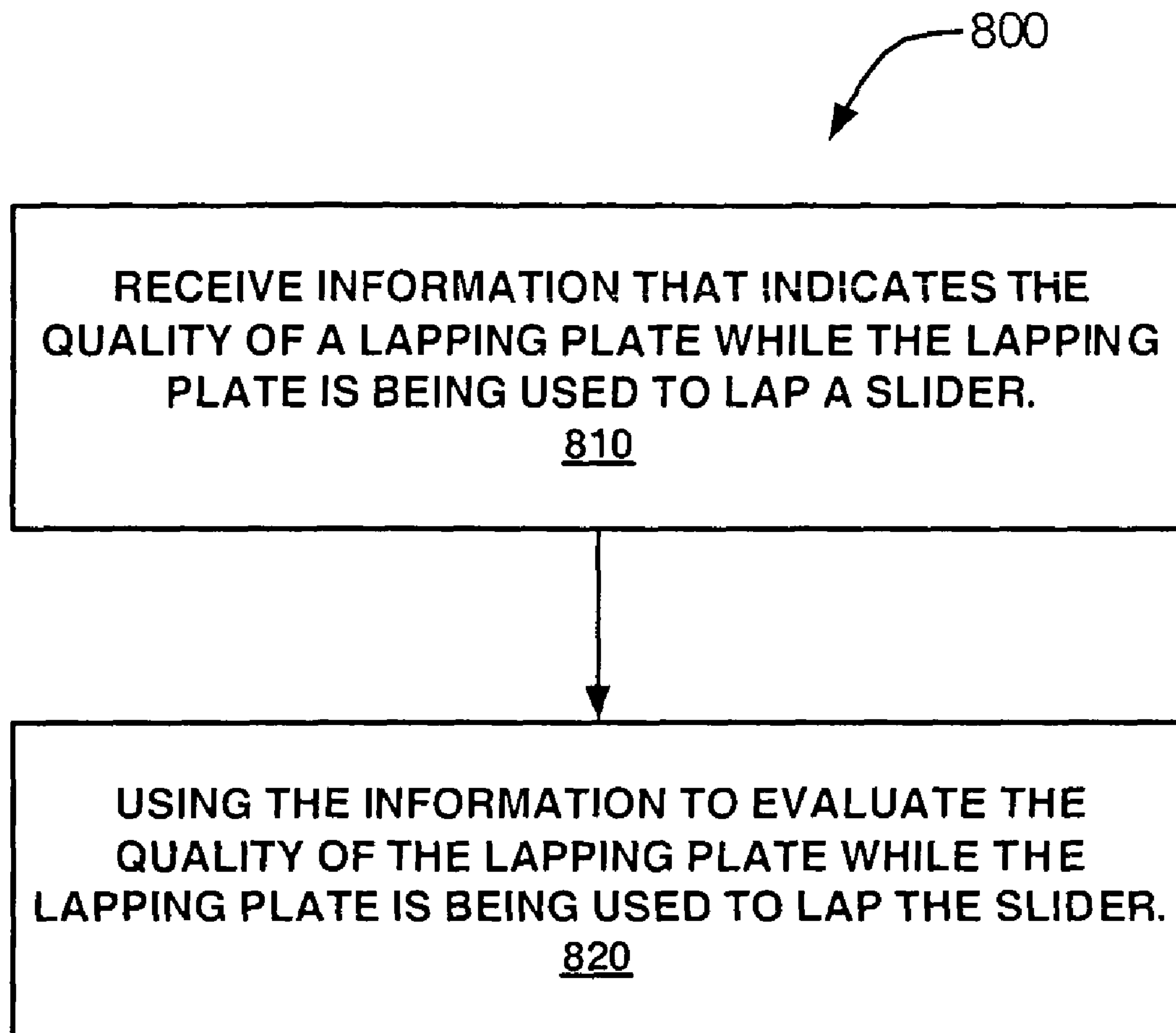


FIG. 7C

**FIG. 8**

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APPARATUS FOR EVALUATING THE
QUALITY OF A LAPPING PLATE

TECHNICAL FIELD

Embodiments of the present invention relate to manufacturing sliders. More specifically, embodiments of the present invention relate to evaluating the quality of a lapping plate while the lapping plate is being used to lap sliders.

BACKGROUND ART

Most computers use disk drives to store data. A disk drive typically includes platters that the data is stored on and a recording head that is used to write data onto the platters and to read the data from the platters. The recording head is manufactured to include what is commonly known as a slider that has aerodynamic properties to fly over a platter. A slider flies over a location on a platter for the purpose of writing data to that location or reading data from that location.

FIG. 1 depicts a side view of a conventional slider. The slider **100** includes a write head **108** for writing data to a platter and a read sensor **106** for reading data from a platter. The read sensor **106** has a height, which is commonly known as a stripe-height **102**. The air bearing surface **104** (ABS) of the slider **100** provides the aerodynamic properties that enables the slider **100** to “fly” over a platter and to be positioned over a desired location on the platter.

In order for the slider **100** as well as the read sensor **106** and the write head **108** to function properly, the ABS **104** needs to be very flat and smooth and the read sensors **106** need to have an appropriate stripe-height **102**. A lapping plate is used for grinding and/or polishing the ABS **104** (commonly referred to as the “lapping process”) in order to achieve the desired smoothness and the desired stripe-height **102**. A lapping plate typically has abrasive particles, such as diamond particles, on its surface that can be used to remove material from the slider **100**. Diamonds are typically embedded into the plate surface using what is commonly known as a “charging process.” It is necessary that the lapping plate be able to remove a sufficient amount of material from the ABS **104** of the slider **100** within an appropriate amount of time.

The dimensions of read heads are shrinking in order to achieve greater recording densities. The smaller dimensions of the read heads makes the sensors **106** more susceptible to damage from mechanical stress that results from the lapping process. Lapping process inherently is a mechanical stress process since the diamond particles have to remove materials from sliders. The quality of a lapping plate may not be good enough to be used for lapping sliders **100** when the lapping plate damages read sensors **106** due to excessive stress even though the lapping plate is very capable of removing material. For example, large scratches may form on the surface of a lapping plate due to the charging process or lapping process. Another example is that many small diamond particles can cluster together to effectively form large diamond particles. In both cases, the stress on read heads may be sufficient to damage sensors **106**.

Typically, sliders **100** are removed from the lapping process, washed and placed in an external tester to determine their (100) magnetic performance and to determine whether the sensors **106** have been damaged by the lapping process. Removing sliders **100** from the lapping process in order to test the sliders **100** makes it difficult to provide fast feed-back to the lapping process.

For these and other reasons, there is a need to evaluate the quality of a lapping plate. For these and other reasons, there is

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also a need to reduce mechanical stress caused by the lapping process which can result in damaged sensors associated with sliders. For these and other reasons, there is also a need to provide fast feed-back to the lapping process.

DISCLOSURE OF THE INVENTION

Embodiments of the present invention pertain to a evaluating the quality of a lapping plate. In one embodiment, an information receiver receives information while the lapping plate is being used to lap a slider. The information indicates the quality of a lapping plate. A quality determiner that evaluates the quality of the lapping plate based on the information while the lapping plate is being used to lap the slider.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention:

FIG. 1 depicts a side view of a conventional slider.

FIG. 2 depicts a block diagram of an apparatus for evaluating the quality of a lapping plate, according to embodiments of the present invention.

FIG. 3A is a bottom view of an area around the read sensor, according to one embodiment.

FIG. 3B is a bottom view of an area around the read sensor that has been smeared, according to one embodiment.

FIG. 4A depicts a graph of measurements of resistance R in Ohms for a slider over time in seconds as the slider is being lapped, according to embodiments of the present invention.

FIG. 4B depicts a graph of measurements of resistance R in terms of sigma/mean for a slider over time in seconds as the slider is being lapped, according to embodiments of the present invention.

FIG. 4C depicts a histogram of sigma/mean, according to one embodiment.

FIGS. 5A-5D depict the pinning layer and the free layer for a sensor in various positions, according to one embodiment of the present invention.

FIGS. 6A and 6B depict a coil that generates a magnetic signal while a slider is being lapped, according to one embodiment.

FIG. 7A depicts a graph where the resistance R is in-phase with the magnetic signal, according to one embodiment.

FIG. 7B depicts a graph where the resistance R is out-of-phase with the magnetic signal, according to one embodiment.

FIG. 7C depicts the percent of sliders from a single wafer, where the percentage of sliders which have reversed pinning layers varies between lapping plates, according to an embodiment.

FIG. 8 depicts a flowchart **800** for a method of evaluating the quality of a lapping plate, according to embodiments of the present invention.

The drawings referred to in this description should not be understood as being drawn to scale except if specifically noted.

PREFERRED EMBODIMENT OF THE
INVENTION

Reference will now be made in detail to various embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with these embodiments, it will be

understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as defined by the appended claims. Furthermore, in the following description of the present invention, numerous specific details are set forth in order to provide a thorough understanding of the present invention. In other instances, well-known methods, procedures, components, and circuits have not been described in detail as not to unnecessarily obscure aspects of the present invention.

Overview

The quality of a lapping plate has a direct affect on a slider's electric and magnetic performance. For example, a lapping plate with inadequate quality, due to either scratches or large diamond clusters on the lapping plate, can damage the read sensors embedded in a slider. Therefore, according to embodiments of the present invention, the quality of a lapping plate is evaluated while the lapping plate is being used to lap a slider (commonly referred to as evaluating "in-situ"). As already stated, using the conventional process, sliders are removed from the lapping process in order to test the magnetic performance of a slider and to determine whether the sensors have been damaged. By providing a method and an apparatus, according to embodiments of the present invention, for evaluating the quality of a lapping plate while the lapping plate is being used to lap a slider, fast feed-back to the lapping process is provided.

Since, according to one embodiment, the quality of a lapping plate is evaluated while the lapping process is being performed, feedback pertaining to the quality of the lapping plate is provided quickly back to the lapping process, according to another embodiment. Further, since according to embodiments of the present invention the lapping plate is being evaluated during the lapping process, the amount of mechanical stress that is being applied to sliders during the lapping process can be constantly evaluated. Thus the probability of damaging sensors is reduced.

FIG. 2 depicts a block diagram of an apparatus for evaluating the quality of a lapping plate, according to embodiments of the present invention. The blocks in FIG. 2 can be arranged differently than as illustrated, and can implement additional or fewer features than what are described herein. Further, the features represented by the blocks in FIG. 2 can be combined in various ways.

As depicted in FIG. 2 the apparatus 200 includes an information receiver 210 and a quality determiner 220. FIG. 2 further depicts a lapping plate 230 that is being used for lapping the ABS 244 of a slider 240. The slider 240 includes a read sensor 246, a write head 248, and an ABS 244. As the lapping process is being performed, information 250 indicating the quality of the lapping plate 230 is received by the information receiver 210 associated with the apparatus 200, according to an embodiment. The information 250 indicating the quality of the lapping plate 230 is provided to the quality determiner 220, which evaluates the quality of the lapping plate 230 based on the information 250 while the lapping plate 230 is being used to lap the slider 240, according to one embodiment. According to embodiments of the present invention, the information 250 can indicate the resistance value associated with the read sensor 246 and/or the information 250 can indicate the amplitude of a magnetic signal detected by a read sensor 246, as will become more evident.

According to one embodiment, the information receiver 210 provides circuitry for measurement and control functions

(referred to herein as "measurement and control circuitry"). The measurement function provides excitation and measurement circuits for the resistance and amplitude measurements and the control function controls the lapping force and speed. According to another embodiment, the quality determiner 220 is a "process controller" that provides software algorithms that can be executed by a microprocessor. The "process controller" can control the lapping process via the "measurement and control circuitry" and determine when the lapping process is completed. The "process controller" can also calculate the resistance, sigma/mean of the resistance, the amplitude and flip rates, as will become more evident. Further, the "process controller" can provide information indicating whether the quality of a lapping plate is acceptable or not acceptable.

Information From the Resistance Measurement

The read sensor 246 is used to read data by detecting the magnetic signals that are recorded on a platter. During the lapping process, debris, some of which are conductive, from the lapping plate 230 and/or from materials removed from the ABS 244 can collect around the read sensor 246 can interfere with the read sensor 246's ability to detect the magnetic signal.

FIG. 3A is a bottom view of an area around the read sensor 302, according to one embodiment. As depicted in FIG. 3A, the read sensor 246 is in between two shields S1, S2. Shields are typically made of metal, and they are used to shield the read sensors from the stray magnetic fields. FIG. 3B is a bottom view of an area around the read sensor that has been smeared. Smearing occurs when conducting particles bridge the read sensors 246 and shields S1 and/or S2. Smearing causes a portion of electric current to find alternative paths through the shields rather than solely through the read sensor so that the resistance measurement of the read sensor 246 is smaller than it should be and does not reflect the true resistance of the read sensor. Since, according to one embodiment, the read sensor's resistance is used for controlling the lapping process and for determining when the quality of a lapping plate has degraded to the point that the lapping plate should no longer be used, inaccurate resistance reading caused by smearing will interfere with controlling the lapping process. Furthermore, any remaining smearing of a finished slider will result in higher noise of the head in the disk drive thus reducing the performance of the head. When the quality of a lapping plate is good, the metal surface of the lapping plate is well protected by the diamond particles, therefore, smearing is much less likely to occur.

According to embodiments of the present invention, fluctuations in resistance can be used for evaluating the quality of a lapping pad. FIGS. 4A, 4B, 4C are graphs of measurements of resistance, according to embodiments of the present invention. FIG. 4A depicts a graph of measurements of resistance R in Ohms for a slider as a function of time as the slider is being lapped, according to embodiments of the present invention. For the sake of illustration, assume that the resistance of the read sensor 246 associated with the slider 240 is being measured as the slider 240 is being lapped using a lapping plate 230 depicted in FIG. 2. Each point of data depicted on the graph in FIG. 4A may represent one measurement or could represent an average of many measurements, of resistance associated with the read sensor 246.

The resistance associated with a read sensor 246 is inversely proportional to the stripe-height of the read sensor 246. For example, as the stripe-height decreases due to the lapping process, the resistance should increase smoothly and

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monotonically as depicted in FIG. 4A from time 0 to approximately time 140 seconds. At approximately time 140 seconds, the resistance R begins to fluctuate, for example, by dropping downwards at point 410. The fluctuation in resistance R can be used as an indication that the quality of the lapping plate 230 has degraded, according to one embodiment. For example, when the resistance R drops (at point 410 for example) by approximately 1% or more, then the quality of the lapping plate 230 is inadequate, according to one embodiment. The lapping plate 230 can be replaced with a new lapping plate if its (230) quality is inadequate.

In some cases when a plate is damaged and smearing occurs, it is possible that an average of resistance R may continue to increase smoothly. resistance fluctuations measured at a higher sampling frequency may provide more sensitive smearing indicator. Sigma is the root-mean-squared of multiple measurements of resistance at high frequency, according to one embodiment, and the mean is the average of those same measurements, according to another embodiment. The percent of sigma resistance over mean resistance (e.g., sigma/mean %), is a more sensitive measurement of the quality of a lapping plate 230, according to one embodiment. For example, sigma can be the root-mean-squared of 1000 measurements and the mean can be the average of the same 1000 measurements. The average of those 1000 measurements is depicted as a function of time in FIG. 4A.

FIG. 4B depicts a graph of measurements of resistance R in terms of sigma/mean for a slider over time in seconds as the slider is being lapped, according to embodiments of the present invention. For the sake of illustration, assume that the resistance of the read sensor 246 associated with the slider 240 is being measured as the slider 240 is being lapped using a lapping plate 230 depicted in FIG. 2. At approximately time 140 seconds, the sigma/mean of resistance begins to fluctuate at point 420. This fluctuation indicates that the quality of the lapping plate 230 has degraded, according to one embodiment. For example, when the sigma/mean measurement of resistance fluctuates by 1% or more, then the quality of the lapping plate 230 is inadequate, according to one embodiment. The lapping plate 230 can be replaced with a new lapping plate if its (230) quality is inadequate.

FIG. 4C depicts a histogram of sigma/mean, according to one embodiment. Lapping plates that are of sufficiently high enough quality to be used for lapping are indicated at point 430 by a sigma/mean below 0.4%. The lapping plates indicated by the 1% (at point 440) or greater sigma/mean suggest that the plate may have been scratched and there is significant resistance fluctuation. This lapping plates should be replaced with new lapping plates immediately, according to one embodiment. The plate with sigma/mean between 0.4% and 1% has marginal quality, according to another embodiment.

According to one embodiment, several measurements of resistance can be received for a time interval and used to calculate an average of resistance, as depicted in FIG. 4A, and/or to calculate a sigma/mean of resistance, as depicted in FIG. 4B. The time interval should be chosen to be short enough such that the resistance does not increase significantly, yet large enough to contain enough sampling points to obtain a statistically meaningful average and sigma/mean. According to one embodiment, the time interval is between 10 milliseconds and 10 seconds.

The information receiver 210 receives information 250 that indicates the resistance value, according to one embodiment, and the quality determiner 220 uses the quality of the resistance measurement to evaluate the quality of a lapping plate 230 while the lapping plate 230 is being used to lap a slider

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240, according to another embodiment. For example, the information receiver 210 can receive a measurement of the resistance value R for a slider 240 or multiple measurements of the resistance R for a slider 240 over time.

The quality determiner 220 can use the one or more measurements of the resistance R to determine whether the resistance R is fluctuating. The quality determiner 220 can calculate an average of more than one measurement of resistance R as depicted in FIG. 4A, a sigma/mean as depicted in FIG. 4B. Further the quality determiner 220 can use the resistance R to determine whether the lapping plate has inadequate quality based on the criteria described herein. Examples of criteria include, but are not limited to, determining that the resistance R drops by approximately 1% or more or determining that the sigma/mean measurement of resistance fluctuates by 1% or more.

Information From the Amplitude Measurement

A read sensor 246 is used to read data, in the form of magnetic signals, from a platter. The magnetic signals are translated into binary 1s and 0s. Typically, a read sensor 246 includes what is commonly known as a pinning layer 502 and a free layer 504 in order to translate the magnetic information into binary 1s and 0s. The moment of the pinned layer 502 is set during the wafer manufacturing process and should stay fixed in the subsequent manufacturing process and final applications in the disk drives. For example, as depicted in FIGS. 5A and 5B the wafer process can set the moment of the pinned layer 502 upwards as indicated by the arrow.

The free layer 504 can rotate in response to the external magnetic signals. The external field can be applied for the purpose of testing, or from the magnetic field associated with information stored on a platter. For example referring to FIG. 5A, when the magnetic signal on the disk represents a binary 1, the moment of the free layer 504 typically is rotated upward as indicated by the arrow. In contrast, referring to FIG. 5B, when the magnetic signal on the disk represents a binary 0, the moment of the free layer 504 typically is swayed downward as indicated by the arrow. The pinning layer 502 is used as a reference to determine whether the moment of the free layer 504 is parallel to the pinning layer 502 (FIG. 5A) or not parallel to the pinning layer 502 (FIG. 5B).

More specifically, the resistance value for a read write head is a function of the angle between the moments of the pinned layer 502 and the free layer 504. The change of the resistance in response to the magnetic signal (e.g., external field) is called amplitude. The moment of the free layer 504 responds to the magnetic signal. In magnetic recording, the free layer 504 rotates following the magnetic field from a platter. Measuring a read head's resistance is used to read back information recorded on a platter.

For the sake of simplicity, the moment of the free layer 504 is depicted as rotating by 180 degrees (as depicted in FIGS. 5A-5D). For example, FIG. 5B depicts the free layer 504 as having rotated 180 degrees with respect to FIG. 5A. Similarly, FIG. 5D depicts the free layer 504 as having rotated 180 degrees with respect to FIG. 5C. However, typically the moment of the free layer 504 rotates by angles much smaller than 180 degrees, and the angle increases with the magnetic fields.

As a lapping plate 230 is damaged by scratches created during the diamond charging process or lapping process, or due to large cluster of diamonds embedded into the plate 230 or some other types of damage, it (230) will exert more mechanical stress on a read sensor 246. This can cause the moment of the pinning layer 502 to reverse its (502) direction

(also commonly known as a “flipped pinning layer 502”) as depicted in FIGS. 5C and 5D. For example, the arrow for the pinning layer 502 as depicted in FIGS. 5C and 5D are pointing downwards (e.g., flipped) whereas in FIGS. 5A and 5B the arrows are pointing upwards. Positive magnetic field which would otherwise lead to the free-layer 504 and pinning layer 502 being parallel will now make those two layers 502, 504 anti-parallel. As a result, the amplitude will become negative, thus, binary 1s will appear to be binary 0s to the read sensor 246 (FIG. 5C) and binary 0s will appear to be binary 1s to the read sensor 246 (FIG. 5D).

According to embodiments of the present invention, the amplitude of the magnetic signal from the platter can be used for evaluating the quality of a lapping plate 230. For example, the amplitude of the magnetic signal from the platter can be used for determining whether the moment of the pinning layer 502 has reversed. For example, FIGS. 6A, and 6B depict using amplitude of the magnetic signal to evaluate the quality of a lapping plate 230, according to embodiments of the present invention.

According to one embodiment, an apparatus that generates a magnetic signal with a known value can be used for determining whether the amplitude has reversed. For example, the apparatus can include a coil that generates a magnetic signal of a known value. FIGS. 6A and 6B depict a coil 600 that generates a magnetic signal H while a slider 240 is being lapped, according to one embodiment. More specifically, FIG. 6A depicts a side view of a slider 240 being lapped by a lapping plate 230. FIG. 6B depicts a top view of the slider 240 being lapped by the lapping plate 230. In both FIGS. 6A and 6B the slider 240 is surrounded by a coil 600 that generates a magnetic signal H (e.g., an external field) with a known value. Although FIGS. 6A and 6B depict the coil 600 surrounding only one slider 240, the coil 600 can surround more than one slider. Further, the coil 600 can be above or below the lapping plate 230. Additionally, the coil 600 can be inside the perimeter of the lapping plate 230 or outside the perimeter of the lapping plate 230.

The read sensor 246 detects the magnetic signal H generated by the coil 600 and the amplitude in response to the magnetic signal H is measured, according to one embodiment. If the pinning layer 502 has not been damaged by the lapping plate 230, then the resistance R will be in-phase with the magnetic signal H generated by the coil 600 as depicted in FIG. 7A, according to one embodiment. However, if the pinning layer 502 has been reversed by the lapping plate 230, then the resistance R will be out-of-phase with the magnetic signal H as depicted in FIG. 7B, according to another embodiment.

For example, amplitude can be measured as dR/R where dR is the change in resistance in response to the magnetic signal H, and R is the average resistance. When the change in resistance R is in-phase with the change in the magnetic signal H, the amplitude is positive as depicted in FIG. 7A. When the change in resistance R is 180 degrees out-of-phase, the amplitude is negative (e.g., reversed amplitude) as depicted in FIG. 7B. More specifically, in FIG. 7A, the amplitude dR/R is positive and is equal to 0.8 Ohm/40 Ohm—2.0%, whereas in FIG. 7B, the resistance has changed 180 degrees out-of-phase as a result of the magnetic field H changing. The amplitude dR/R is negative and is equal to -0.8 Ohm/40 Ohm=-2.0%.

According to another embodiment, the percent of sliders with reversed pinning layers 502 can be used to evaluate the quality of a lapping plate 230. For example, the sliders from a single wafer can be analyzed to determine what percent of the sliders had reversed pinning layers 502, according to

another embodiment. FIG. 7C depicts the percent of sliders from a single wafer, where the percentage of sliders which have reversed pinning layers varies between lapping plates, according to an embodiment. As depicted in FIG. 7C, each point is the average over a plurality of sliders, such as 16 sliders for example. Some of the sliders were lapped with a lapping plate 1 and some of the slides were lapped with a lapping plate 2. As depicted in FIG. 7C, lapping plate 1 resulted in approximately 14% (at point 710) of the sliders having reversed pinning layers 502 and lapping plate 2 resulted in approximately 3.5% (at point 720) of the sliders having reversed pinning layers 502. Therefore, lapping plate 1 has worse quality than lapping plate 2. According to one embodiment, if a lapping plate causes a certain percentage, such as 4% as depicted in 7C, or more sliders to have a reversed a pinning layer, then the lapping plate has inadequate quality. In this case, the lapping plate 2 can be replaced with a new lapping plate.

The percentage of sliders with reversed pinning layers 502 is largely dependent on the design of the head and the quality of the head. The criteria that is chosen for evaluating the quality of a lapping plate is related to the design and structure of a head. For example, although FIG. 7C depicts 4% as the criteria, another percentage may be used for a head with a different design and structure.

The information receiver 210 receives information 250 that indicates the amplitude of the magnetic signal, according to one embodiment, and the quality determiner 220 uses amplitude to evaluate the quality of a lapping plate 230 while the lapping plate 230 is being used to lap a slider 240, according to another embodiment. For example, the information receiver 210 can receive a measurement of the amplitude or more than one measurement of the amplitude for a slider 240 over time. The quality determiner 220 can use the one or more measurements of the amplitude to determine whether amplitude has reversed.

The quality determiner 220 can use the amplitude to calculate the percent of sliders with reversed pinning layers 502 (also commonly known as “flip rate”) as depicted in FIG. 7C. Further the quality determiner 220 can use the calculated percent of sliders to determine whether the lapping plate has inadequate quality based on the criteria described herein. The quality determiner 220 can compare the calculated percent of sliders with reversed pinning layers 502 to the chosen criteria and determine whether the lapping plate is adequate or not, according to embodiments described herein. More specifically, as depicted in FIG. 7C, plate 1 can be replaced since plate 1 resulted in more than 4% of the sliders that were lapped with plate 1 having reversed pinning layers 502.

Method of Evaluating the Quality of a Lapping Plate

FIG. 8 depicts a flowchart 800 for a method of evaluating the quality of a lapping plate, according to embodiments of the present invention. Although specific steps are disclosed in flowchart 800, such steps are exemplary. That is, embodiments of the present invention are well suited to performing various other steps or variations of the steps recited in flowchart 800. It is appreciated that the steps in flowchart 800 may be performed in an order different than presented, and that not all of the steps in flowchart 800 may be performed.

In step 810, information that indicates the quality of a lapping plate is received while the lapping plate is being used to lap a slider 240. For example, information 250 indicating the quality of the lapping plate 230 is received by the information receiver 210 associated with the apparatus 200. The information 250 can indicate the amount of resistance asso-

ciated with the slider **240** and/or the information **250** can indicate the amplitude of a magnetic signal detected by a read sensor **246**.

More specifically in one example, the information receiver **210** can receive a measurement of the amount of resistance **R** for a slider **240** or more than one measurement of the resistance **R** for a slider **240** over time. In another example, the information receiver **210** can receive a measurement of the amplitude or more than one measurement of the amplitude for a slider **240** over time.

In step **820**, the information is used to evaluate the quality of the lapping plate while the lapping plate is being used to lap the slider **240**. For example, the information **250** indicating the quality of the lapping plate **230** is provided to the quality determiner **250** which evaluates the quality of the lapping plate **230** based on the information **250** while the lapping plate **230** is being used to lap the slider **240**.

More specifically in one example, the quality determiner **220** can use the one or more measurements of the resistance **R** to determine whether the resistance **R** is fluctuating. The quality determiner **220** can calculate an average of more than one measurement of resistance **R** as depicted in FIG. 4A, a sigma/mean as depicted in FIG. 4B, and/or a histogram as depicted in FIG. 4C. Further the quality determiner **220** can use the resistance **R** to determine whether the lapping plate has inadequate quality based on the criteria described herein. Examples of criteria include, but are not limited to, determining that the resistance **R** drops by approximately 1% or more or determining that the sigma/mean measurement of resistance fluctuates by 1% or more. The lapping plate **230** can be replaced if it (**230**) has inadequate quality.

In another example, the quality determiner **220** can use amplitude to calculate the percent of sliders with reversed pinning layers **502** as depicted in FIG. 7C. Further, the quality determiner **220** can use the calculated percent of sliders which have reversed amplitude to determine whether the lapping plate has inadequate quality based on the criteria described herein. Examples of criteria include, but are not limited to, determining whether a slider has caused 4% or more sliders to have reversed pinning layers. The lapping plate **230** can be replaced if it (**230**) has inadequate quality.

CONCLUSION

Although many of the embodiments described herein referred to reducing the probability of damaging a read sensor **246**, embodiments of the present invention can also be used for reducing the probability of damage to a write head **248** as well.

What is claimed is:

1. An apparatus for evaluating quality of a lapping plate, the apparatus comprising:

a shield configured for shielding at least one side of a read sensor disposed within a slider from particles associated with the lapping plate, the read sensor comprising a free layer and pinning layers;

an information receiver configured for receiving information from the read sensor while the lapping plate is being used to lap the slider, wherein the information from the read sensor indicates the quality of a lapping plate; and

a quality determiner configured for evaluating the quality of the lapping plate based on the information from the read sensor while the lapping plate is being used to lap the slider and configured for determining when the lapping plate has inadequate quality based on a criterion.

2. The apparatus of claim 1, wherein the information from the read sensor indicates resistance associated with the read sensor.

3. The apparatus of claim 2, wherein the quality determiner is further configured to use the information from the read sensor to determine whether the resistance is fluctuating.

4. The apparatus of claim 2, wherein the quality determiner is further configured to determine whether the resistance drops by more than a certain percentage, and to determine the quality of the lapping plate based on the criterion that if the resistance drops by more than the certain percentage then the quality of the lapping plate is inadequate.

5. The apparatus of claim 4, wherein the certain percentage is 1%.

6. The apparatus of claim 2, wherein the quality determiner is further configured to use the information from the read sensor that indicates resistance to calculate an average of the resistance and to use the average of the resistance to evaluate the quality of the lapping plate.

7. The apparatus of claim 2, wherein the quality determiner is further configured to use measurements of the resistance that the information receiver received over a time interval that is between 10 milliseconds and 10 seconds to compute the average of the resistance.

8. The apparatus of claim 2, wherein the quality determiner is further configured to determine whether the average of the resistance fluctuates by more than a certain percentage and to determine the quality of the lapping plate based on the criterion that if the average of the resistance fluctuates by more than the certain percentage then the quality of the lapping plate is inadequate.

9. The apparatus of claim 8, wherein the certain percentage is 1%.

10. The apparatus of claim 2, wherein the quality determiner is further configured to use the information from the read sensor that indicates resistance to calculate a sigma resistance divided by mean resistance and to use the sigma resistance divided by the mean resistance to evaluate the quality of the lapping plate.

11. The apparatus of claim 10, wherein the quality determiner is further configured to use measurements of the resistance received over a time interval that is between 10 milliseconds and 10 seconds to compute the sigma resistance and the mean resistance.

12. The apparatus of claim 2, wherein the quality determiner is further configured to determine whether a percent of sigma resistance divided by mean resistance is greater than a certain percentage and to determine the quality of the lapping plate based on the criterion that if the percent of sigma resistance divided by the mean resistance is greater than the certain percentage then the quality of the lapping plate is inadequate.

13. The apparatus of claim 12, wherein the certain percentage is 1%.

14. The apparatus of claim 1, wherein the information from the read sensor indicates amplitude associated with a magnetic signal detected by the read sensor.

15. The apparatus of claim 14, wherein the quality determiner is further configured to use the information from the read sensor that indicates the amplitude to determine whether the amplitude is reversed.

16. The apparatus of claim 14, wherein the quality determiner is further configured to determine whether a percentage of sliders being lapped with the lapping plate having the read sensor with a pinning layer having reversed amplitude is greater than a certain percentage and to determine the quality of the lapping plate based on the criterion that if the percent-

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age of sliders being lapped with the lapping plate having the read sensor with the pinning layer having reversed amplitude is greater than the certain percentage then the quality of the lapping plate is inadequate.

17. The apparatus of claim **16**, wherein the certain percent- 5 age is 4%.

18. The apparatus of claim **1**, wherein the quality determiner is further configured for evaluating the quality of the lapping plate based on the information from the read sensor selected from the group consisting of information from the

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read sensor that provides a smearing indicator of the read sensor and information from the read sensor used to determine whether a moment of a pinning layer of the read sensor has reversed.

19. The apparatus of claim **1**, wherein the quality determiner is further configured to use the information from the read sensor to reduce the probability of damaging the read sensor associated with the slider.

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